

Measurement of the Lifetime Difference in the  $B_s^0$  System

V.M. Abazov,<sup>35</sup> B. Abbott,<sup>72</sup> M. Abolins,<sup>63</sup> B.S. Acharya,<sup>29</sup> M. Adams,<sup>50</sup> T. Adams,<sup>48</sup> M. Agelou,<sup>18</sup> J.-L. Agram,<sup>19</sup> S.H. Ahn,<sup>31</sup> M. Ahsan,<sup>57</sup> G.D. Alexeev,<sup>35</sup> G. Alkhazov,<sup>39</sup> A. Alton,<sup>62</sup> G. Alverson,<sup>61</sup> G.A. Alves,<sup>2</sup> M. Anastasoae,<sup>34</sup> T. Andeen,<sup>52</sup> S. Anderson,<sup>44</sup> B. Andrieu,<sup>17</sup> Y. Arnoud,<sup>14</sup> M. Arov,<sup>51</sup> A. Askew,<sup>48</sup> B. Åsman,<sup>40</sup> A.C.S. Assis Jesus,<sup>3</sup> O. Atramentov,<sup>55</sup> C. Autermann,<sup>21</sup> C. Avila,<sup>8</sup> F. Badaud,<sup>13</sup> A. Baden,<sup>59</sup> L. Bagby,<sup>51</sup> B. Baldin,<sup>49</sup> P.W. Balm,<sup>33</sup> P. Banerjee,<sup>29</sup> S. Banerjee,<sup>29</sup> E. Barberis,<sup>61</sup> P. Bargassa,<sup>76</sup> P. Baringer,<sup>56</sup> C. Barnes,<sup>42</sup> J. Barreto,<sup>2</sup> J.F. Bartlett,<sup>49</sup> U. Bassler,<sup>17</sup> D. Bauer,<sup>53</sup> A. Bean,<sup>56</sup> S. Beauceron,<sup>17</sup> M. Begalli,<sup>3</sup> M. Begel,<sup>68</sup> A. Bellavance,<sup>65</sup> S.B. Beri,<sup>27</sup> G. Bernardi,<sup>17</sup> R. Bernhard,<sup>49,\*</sup> I. Bertram,<sup>41</sup> M. Besançon,<sup>18</sup> R. Beuselinck,<sup>42</sup> V.A. Bezzubov,<sup>38</sup> P.C. Bhat,<sup>49</sup> V. Bhatnagar,<sup>27</sup> M. Binder,<sup>25</sup> C. Biscarat,<sup>41</sup> K.M. Black,<sup>60</sup> I. Blackler,<sup>42</sup> G. Blazey,<sup>51</sup> F. Blekman,<sup>42</sup> S. Blessing,<sup>48</sup> D. Bloch,<sup>19</sup> U. Blumenschein,<sup>23</sup> A. Boehnlein,<sup>49</sup> O. Boeriu,<sup>54</sup> T.A. Bolton,<sup>57</sup> F. Borchering,<sup>49</sup> G. Borissov,<sup>41</sup> K. Bos,<sup>33</sup> T. Bose,<sup>67</sup> A. Brandt,<sup>74</sup> R. Brock,<sup>63</sup> G. Brooijmans,<sup>67</sup> A. Bross,<sup>49</sup> N.J. Buchanan,<sup>48</sup> D. Buchholz,<sup>52</sup> M. Buehler,<sup>50</sup> V. Buescher,<sup>23</sup> S. Burdin,<sup>49</sup> S. Burke,<sup>44</sup> T.H. Burnett,<sup>78</sup> E. Busato,<sup>17</sup> C.P. Buszello,<sup>42</sup> J.M. Butler,<sup>60</sup> J. Cammin,<sup>68</sup> S. Caron,<sup>33</sup> W. Carvalho,<sup>3</sup> B.C.K. Casey,<sup>73</sup> N.M. Cason,<sup>54</sup> H. Castilla-Valdez,<sup>32</sup> S. Chakrabarti,<sup>29</sup> D. Chakraborty,<sup>51</sup> K.M. Chan,<sup>68</sup> A. Chandra,<sup>29</sup> D. Chapin,<sup>73</sup> F. Charles,<sup>19</sup> E. Cheu,<sup>44</sup> D.K. Cho,<sup>60</sup> S. Choi,<sup>47</sup> B. Choudhary,<sup>28</sup> T. Christiansen,<sup>25</sup> L. Christofek,<sup>56</sup> D. Claes,<sup>65</sup> B. Clément,<sup>19</sup> C. Clément,<sup>40</sup> Y. Coadou,<sup>5</sup> M. Cooke,<sup>76</sup> W.E. Cooper,<sup>49</sup> D. Coppage,<sup>56</sup> M. Corcoran,<sup>76</sup> A. Cothenet,<sup>15</sup> M.-C. Cousinou,<sup>15</sup> B. Cox,<sup>43</sup> S. Crépe-Renaudin,<sup>14</sup> D. Cutts,<sup>73</sup> H. da Motta,<sup>2</sup> M. Das,<sup>58</sup> B. Davies,<sup>41</sup> G. Davies,<sup>42</sup> G.A. Davis,<sup>52</sup> K. De,<sup>74</sup> P. de Jong,<sup>33</sup> S.J. de Jong,<sup>34</sup> E. De La Cruz-Burelo,<sup>62</sup> C. De Oliveira Martins,<sup>3</sup> S. Dean,<sup>43</sup> J.D. Degenhardt,<sup>62</sup> F. Déliot,<sup>18</sup> M. Demarteau,<sup>49</sup> R. Demina,<sup>68</sup> P. Demine,<sup>18</sup> D. Denisov,<sup>49</sup> S.P. Denisov,<sup>38</sup> S. Desai,<sup>69</sup> H.T. Diehl,<sup>49</sup> M. Diesburg,<sup>49</sup> M. Doidge,<sup>41</sup> H. Dong,<sup>69</sup> S. Doulas,<sup>61</sup> L.V. Dudko,<sup>37</sup> L. Duflot,<sup>16</sup> S.R. Dugad,<sup>29</sup> A. Duperrin,<sup>15</sup> J. Dyer,<sup>63</sup> A. Dyshkant,<sup>51</sup> M. Eads,<sup>51</sup> D. Edmunds,<sup>63</sup> T. Edwards,<sup>43</sup> J. Ellison,<sup>47</sup> J. Elmsheuser,<sup>25</sup> V.D. Elvira,<sup>49</sup> S. Eno,<sup>59</sup> P. Ermolov,<sup>37</sup> O.V. Eroshin,<sup>38</sup> J. Estrada,<sup>49</sup> H. Evans,<sup>67</sup> A. Evdokimov,<sup>36</sup> V.N. Evdokimov,<sup>38</sup> J. Fast,<sup>49</sup> S.N. Fatakia,<sup>60</sup> L. Feligioni,<sup>60</sup> A.V. Ferapontov,<sup>38</sup> T. Ferbel,<sup>68</sup> F. Fiedler,<sup>25</sup> F. Filthaut,<sup>34</sup> W. Fisher,<sup>49</sup> H.E. Fisk,<sup>49</sup> I. Fleck,<sup>23</sup> M. Fortner,<sup>51</sup> H. Fox,<sup>23</sup> S. Fu,<sup>49</sup> S. Fuess,<sup>49</sup> T. Gadfort,<sup>78</sup> C.F. Galea,<sup>34</sup> E. Gallas,<sup>49</sup> E. Galyaev,<sup>54</sup> C. Garcia,<sup>68</sup> A. Garcia-Bellido,<sup>78</sup> J. Gardner,<sup>56</sup> V. Gavrilov,<sup>36</sup> A. Gay,<sup>19</sup> P. Gay,<sup>13</sup> D. Gelé,<sup>19</sup> R. Gelhaus,<sup>47</sup> K. Genser,<sup>49</sup> C.E. Gerber,<sup>50</sup> Y. Gershtein,<sup>48</sup> D. Gillberg,<sup>5</sup> G. Ginther,<sup>68</sup> T. Golling,<sup>22</sup> N. Gollub,<sup>40</sup> B. Gómez,<sup>8</sup> K. Gounder,<sup>49</sup> A. Goussiou,<sup>54</sup> P.D. Grannis,<sup>69</sup> S. Greder,<sup>3</sup> H. Greenlee,<sup>49</sup> Z.D. Greenwood,<sup>58</sup> E.M. Gregores,<sup>4</sup> Ph. Gris,<sup>13</sup> J.-F. Grivaz,<sup>16</sup> L. Groer,<sup>67</sup> S. Grünendahl,<sup>49</sup> M.W. Grünewald,<sup>30</sup> S.N. Gurzhiev,<sup>38</sup> G. Gutierrez,<sup>49</sup> P. Gutierrez,<sup>72</sup> A. Haas,<sup>67</sup> N.J. Hadley,<sup>59</sup> S. Hagopian,<sup>48</sup> I. Hall,<sup>72</sup> R.E. Hall,<sup>46</sup> C. Han,<sup>62</sup> L. Han,<sup>7</sup> K. Hanagaki,<sup>49</sup> K. Harder,<sup>57</sup> A. Harel,<sup>26</sup> R. Harrington,<sup>61</sup> J.M. Hauptman,<sup>55</sup> R. Hauser,<sup>63</sup> J. Hays,<sup>52</sup> T. Hebbeker,<sup>21</sup> D. Hedin,<sup>51</sup> J.M. Heinmiller,<sup>50</sup> A.P. Heinson,<sup>47</sup> U. Heintz,<sup>60</sup> C. Hensel,<sup>56</sup> G. Hesketh,<sup>61</sup> M.D. Hildreth,<sup>54</sup> R. Hirosky,<sup>77</sup> J.D. Hobbs,<sup>69</sup> B. Hoeneisen,<sup>12</sup> M. Hohlfield,<sup>24</sup> S.J. Hong,<sup>31</sup> R. Hooper,<sup>73</sup> P. Houben,<sup>33</sup> Y. Hu,<sup>69</sup> J. Huang,<sup>53</sup> V. Hynek,<sup>9</sup> I. Iashvili,<sup>47</sup> R. Illingworth,<sup>49</sup> A.S. Ito,<sup>49</sup> S. Jabeen,<sup>56</sup> M. Jaffré,<sup>16</sup> S. Jain,<sup>72</sup> V. Jain,<sup>70</sup> K. Jakobs,<sup>23</sup> A. Jenkins,<sup>42</sup> R. Jesik,<sup>42</sup> K. Johns,<sup>44</sup> M. Johnson,<sup>49</sup> A. Jonckheere,<sup>49</sup> P. Jonsson,<sup>42</sup> A. Juste,<sup>49</sup> D. Käfer,<sup>21</sup> S. Kahn,<sup>70</sup> E. Kajfasz,<sup>15</sup> A.M. Kalinin,<sup>35</sup> J. Kalk,<sup>63</sup> D. Karmanov,<sup>37</sup> J. Kasper,<sup>60</sup> I. Katsanos,<sup>67</sup> D. Kau,<sup>48</sup> R. Kaur,<sup>27</sup> R. Kehoe,<sup>75</sup> S. Kermiche,<sup>15</sup> S. Kesisoglou,<sup>73</sup> A. Khanov,<sup>68</sup> A. Kharchilava,<sup>54</sup> Y.M. Kharzheev,<sup>35</sup> H. Kim,<sup>74</sup> T.J. Kim,<sup>31</sup> B. Klima,<sup>49</sup> J.M. Kohli,<sup>27</sup> J.-P. Konrath,<sup>23</sup> M. Kopal,<sup>72</sup> V.M. Korablev,<sup>38</sup> J. Kotcher,<sup>70</sup> B. Kothari,<sup>67</sup> A. Koubarovsky,<sup>37</sup> A.V. Kozelov,<sup>38</sup> J. Kozminski,<sup>63</sup> A. Kryemadhi,<sup>77</sup> S. Krzywdzinski,<sup>49</sup> Y. Kulik,<sup>49</sup> A. Kumar,<sup>28</sup> S. Kunori,<sup>59</sup> A. Kupco,<sup>11</sup> T. Kurča,<sup>20</sup> J. Kvita,<sup>9</sup> S. Lager,<sup>40</sup> N. Lahrichi,<sup>18</sup> G. Landsberg,<sup>73</sup> J. Lazofflores,<sup>48</sup> A.-C. Le Bihan,<sup>19</sup> P. Lebrun,<sup>20</sup> W.M. Lee,<sup>48</sup> A. Leflat,<sup>37</sup> F. Lehner,<sup>49,\*</sup> C. Leonidopoulos,<sup>67</sup> J. Leveque,<sup>44</sup> P. Lewis,<sup>42</sup> J. Li,<sup>74</sup> Q.Z. Li,<sup>49</sup> J.G.R. Lima,<sup>51</sup> D. Lincoln,<sup>49</sup> S.L. Linn,<sup>48</sup> J. Linnemann,<sup>63</sup> V.V. Lipaev,<sup>38</sup> R. Lipton,<sup>49</sup> L. Lobo,<sup>42</sup> A. Lobodenko,<sup>39</sup> M. Lokajicek,<sup>11</sup> A. Lounis,<sup>19</sup> P. Love,<sup>41</sup> H.J. Lubatti,<sup>78</sup> L. Lueking,<sup>49</sup> M. Lynker,<sup>54</sup> A.L. Lyon,<sup>49</sup> A.K.A. Maciel,<sup>51</sup> R.J. Madaras,<sup>45</sup> P. Mättig,<sup>26</sup> C. Magass,<sup>21</sup> A. Magerkurth,<sup>62</sup> A.-M. Magnan,<sup>14</sup> N. Makovec,<sup>16</sup> P.K. Mal,<sup>29</sup> H.B. Malbouisson,<sup>3</sup> S. Malik,<sup>65</sup> V.L. Malyshev,<sup>35</sup> H.S. Mao,<sup>6</sup> Y. Maravin,<sup>49</sup> M. Martens,<sup>49</sup> S.E.K. Mattingly,<sup>73</sup> A.A. Mayorov,<sup>38</sup> R. McCarthy,<sup>69</sup> R. McCroskey,<sup>44</sup> D. Meder,<sup>24</sup> A. Melnitchouk,<sup>64</sup> A. Mendes,<sup>15</sup> D. Mendoza,<sup>8</sup> M. Merkin,<sup>37</sup> K.W. Merritt,<sup>49</sup> A. Meyer,<sup>21</sup> J. Meyer,<sup>22</sup> M. Michaut,<sup>18</sup> H. Miettinen,<sup>76</sup> J. Mitrevski,<sup>67</sup> J. Molina,<sup>3</sup> N.K. Mondal,<sup>29</sup> R.W. Moore,<sup>5</sup> T. Moulik,<sup>56</sup> G.S. Muanza,<sup>20</sup> M. Mulders,<sup>49</sup> L. Mundim,<sup>3</sup> Y.D. Mutaf,<sup>69</sup> E. Nagy,<sup>15</sup> M. Naimuddin,<sup>28</sup> M. Narain,<sup>60</sup> N.A. Naumann,<sup>34</sup> H.A. Neal,<sup>62</sup> J.P. Negret,<sup>8</sup> S. Nelson,<sup>48</sup> P. Neustroev,<sup>39</sup> C. Noeding,<sup>23</sup> A. Nomerotski,<sup>49</sup> S.F. Novaes,<sup>4</sup> T. Nunnemann,<sup>25</sup>

E. Nurse,<sup>43</sup> V. O'Dell,<sup>49</sup> D.C. O'Neil,<sup>5</sup> V. Oguri,<sup>3</sup> N. Oliveira,<sup>3</sup> N. Oshima,<sup>49</sup> G.J. Otero y Garzón,<sup>50</sup> P. Padley,<sup>76</sup> N. Parashar,<sup>58</sup> S.K. Park,<sup>31</sup> J. Parsons,<sup>67</sup> R. Partridge,<sup>73</sup> N. Parua,<sup>69</sup> A. Patwa,<sup>70</sup> G. Pawloski,<sup>76</sup> P.M. Perea,<sup>47</sup> E. Perez,<sup>18</sup> P. Pétroff,<sup>16</sup> M. Petteni,<sup>42</sup> R. Piegai,<sup>1</sup> M.-A. Pleier,<sup>68</sup> P.L.M. Podesta-Lerma,<sup>32</sup> V.M. Podstavkov,<sup>49</sup> Y. Pogorelov,<sup>54</sup> M.-E. Pol,<sup>2</sup> A. Pompoš,<sup>72</sup> B.G. Pope,<sup>63</sup> W.L. Prado da Silva,<sup>3</sup> H.B. Prosper,<sup>48</sup> S. Protopopescu,<sup>70</sup> J. Qian,<sup>62</sup> A. Quadt,<sup>22</sup> B. Quinn,<sup>64</sup> K.J. Rani,<sup>29</sup> K. Ranjan,<sup>28</sup> P.A. Rapidis,<sup>49</sup> P.N. Ratoff,<sup>41</sup> S. Reucroft,<sup>61</sup> M. Rijssenbeek,<sup>69</sup> I. Ripp-Baudot,<sup>19</sup> F. Rizatdinova,<sup>57</sup> S. Robinson,<sup>42</sup> R.F. Rodrigues,<sup>3</sup> C. Royon,<sup>18</sup> P. Rubinov,<sup>49</sup> R. Ruchti,<sup>54</sup> V.I. Rud,<sup>37</sup> G. Sajot,<sup>14</sup> A. Sánchez-Hernández,<sup>32</sup> M.P. Sanders,<sup>59</sup> A. Santoro,<sup>3</sup> G. Savage,<sup>49</sup> L. Sawyer,<sup>58</sup> T. Scanlon,<sup>42</sup> D. Schaile,<sup>25</sup> R.D. Schamberger,<sup>69</sup> Y. Scheglov,<sup>39</sup> H. Schellman,<sup>52</sup> P. Schieferdecker,<sup>25</sup> C. Schmitt,<sup>26</sup> C. Schwanenberger,<sup>22</sup> A. Schwartzman,<sup>66</sup> R. Schwienhorst,<sup>63</sup> S. Sengupta,<sup>48</sup> H. Severini,<sup>72</sup> E. Shabalina,<sup>50</sup> M. Shamim,<sup>57</sup> V. Shary,<sup>18</sup> A.A. Shchukin,<sup>38</sup> W.D. Shephard,<sup>54</sup> R.K. Shivpuri,<sup>28</sup> D. Shpakov,<sup>61</sup> R.A. Sidwell,<sup>57</sup> V. Simak,<sup>10</sup> V. Sirotenko,<sup>49</sup> P. Skubic,<sup>72</sup> P. Slattey,<sup>68</sup> R.P. Smith,<sup>49</sup> K. Smolek,<sup>10</sup> G.R. Snow,<sup>65</sup> J. Snow,<sup>71</sup> S. Snyder,<sup>70</sup> S. Söldner-Rembold,<sup>43</sup> X. Song,<sup>51</sup> L. Sonnenschein,<sup>17</sup> A. Sopczak,<sup>41</sup> M. Sosebee,<sup>74</sup> K. Soustruznik,<sup>9</sup> M. Souza,<sup>2</sup> B. Spurlock,<sup>74</sup> N.R. Stanton,<sup>57</sup> J. Stark,<sup>14</sup> J. Steele,<sup>58</sup> K. Stevenson,<sup>53</sup> V. Stolin,<sup>36</sup> A. Stone,<sup>50</sup> D.A. Stoyanova,<sup>38</sup> J. Strandberg,<sup>40</sup> M.A. Strang,<sup>74</sup> M. Strauss,<sup>72</sup> R. Ströhmer,<sup>25</sup> D. Strom,<sup>52</sup> M. Strovink,<sup>45</sup> L. Stutte,<sup>49</sup> S. Sumowidagdo,<sup>48</sup> A. Sznajder,<sup>3</sup> M. Talby,<sup>15</sup> P. Tamburello,<sup>44</sup> W. Taylor,<sup>5</sup> P. Telford,<sup>43</sup> J. Temple,<sup>44</sup> M. Titov,<sup>23</sup> M. Tomoto,<sup>49</sup> T. Toole,<sup>59</sup> J. Torborg,<sup>58</sup> S. Towers,<sup>69</sup> T. Trefzger,<sup>24</sup> S. Trincas-Duvold,<sup>17</sup> D. Tsybychev,<sup>69</sup> B. Tuchming,<sup>18</sup> C. Tully,<sup>66</sup> A.S. Turcot,<sup>43</sup> P.M. Tuts,<sup>67</sup> L. Uvarov,<sup>39</sup> S. Uvarov,<sup>39</sup> S. Uzunyan,<sup>51</sup> B. Vachon,<sup>5</sup> P.J. van den Berg,<sup>33</sup> R. Van Kooten,<sup>53</sup> W.M. van Leeuwen,<sup>33</sup> N. Varelas,<sup>50</sup> E.W. Varnes,<sup>44</sup> A. Vartapetian,<sup>74</sup> I.A. Vasilyev,<sup>38</sup> M. Vaupel,<sup>26</sup> P. Verdier,<sup>20</sup> L.S. Vertogradov,<sup>35</sup> M. Verzocchi,<sup>49</sup> F. Villeneuve-Seguer,<sup>42</sup> J.-R. Vlimant,<sup>17</sup> E. Von Toerne,<sup>57</sup> M. Vreeswijk,<sup>33</sup> T. Vu Anh,<sup>16</sup> H.D. Wahl,<sup>48</sup> L. Wang,<sup>59</sup> J. Warchol,<sup>54</sup> G. Watts,<sup>78</sup> M. Wayne,<sup>54</sup> M. Weber,<sup>49</sup> H. Weerts,<sup>63</sup> N. Worms,<sup>22</sup> M. Wetstein,<sup>59</sup> A. White,<sup>74</sup> V. White,<sup>49</sup> D. Wicke,<sup>49</sup> D.A. Wijngaarden,<sup>34</sup> G.W. Wilson,<sup>56</sup> S.J. Wimpenny,<sup>47</sup> J. Wittlin,<sup>60</sup> M. Wobisch,<sup>49</sup> J. Womersley,<sup>49</sup> D.R. Wood,<sup>61</sup> T.R. Wyatt,<sup>43</sup> Y. Xie,<sup>73</sup> Q. Xu,<sup>62</sup> N. Xuan,<sup>54</sup> S. Yacoub,<sup>52</sup> R. Yamada,<sup>49</sup> M. Yan,<sup>59</sup> T. Yasuda,<sup>49</sup> Y.A. Yatsunenko,<sup>35</sup> Y. Yen,<sup>26</sup> K. Yip,<sup>70</sup> H.D. Yoo,<sup>73</sup> S.W. Youn,<sup>52</sup> J. Yu,<sup>74</sup> A. Yurkewicz,<sup>69</sup> A. Zabi,<sup>16</sup> A. Zatserklyaniy,<sup>51</sup> M. Zdzrazil,<sup>69</sup> C. Zeitnitz,<sup>24</sup> D. Zhang,<sup>49</sup> X. Zhang,<sup>72</sup> T. Zhao,<sup>78</sup> Z. Zhao,<sup>62</sup> B. Zhou,<sup>62</sup> J. Zhu,<sup>69</sup> M. Zielinski,<sup>68</sup> D. Zieminska,<sup>53</sup> A. Zieminski,<sup>53</sup> R. Zitoun,<sup>69</sup> V. Zutshi,<sup>51</sup> and E.G. Zverev<sup>37</sup>  
(DØ Collaboration)

<sup>1</sup> Universidad de Buenos Aires, Buenos Aires, Argentina

<sup>2</sup> LAFEX, Centro Brasileiro de Pesquisas Físicas, Rio de Janeiro, Brazil

<sup>3</sup> Universidade do Estado do Rio de Janeiro, Rio de Janeiro, Brazil

<sup>4</sup> Instituto de Física Teórica, Universidade Estadual Paulista, São Paulo, Brazil

<sup>5</sup> University of Alberta, Edmonton, Alberta, Canada, Simon Fraser University, Burnaby, British Columbia, Canada, York University, Toronto, Ontario, Canada, and McGill University, Montreal, Quebec, Canada

<sup>6</sup> Institute of High Energy Physics, Beijing, People's Republic of China

<sup>7</sup> University of Science and Technology of China, Hefei, People's Republic of China

<sup>8</sup> Universidad de los Andes, Bogotá, Colombia

<sup>9</sup> Center for Particle Physics, Charles University, Prague, Czech Republic

<sup>10</sup> Czech Technical University, Prague, Czech Republic

<sup>11</sup> Center for Particle Physics, Institute of Physics, Academy of Sciences of the Czech Republic, Prague, Czech Republic

<sup>12</sup> Universidad San Francisco de Quito, Quito, Ecuador

<sup>13</sup> Laboratoire de Physique Corpusculaire, IN2P3-CNRS, Université Blaise Pascal, Clermont-Ferrand, France

<sup>14</sup> Laboratoire de Physique Subatomique et de Cosmologie, IN2P3-CNRS, Université de Grenoble 1, Grenoble, France

<sup>15</sup> CPPM, IN2P3-CNRS, Université de la Méditerranée, Marseille, France

<sup>16</sup> IN2P3-CNRS, Laboratoire de l'Accélérateur Linéaire, Orsay, France

<sup>17</sup> LPNHE, IN2P3-CNRS, Universités Paris VI and VII, Paris, France

<sup>18</sup> DAPNIA/Service de Physique des Particules, CEA, Saclay, France

<sup>19</sup> IReS, IN2P3-CNRS, Université Louis Pasteur, Strasbourg, France, and Université de Haute Alsace, Mulhouse, France

<sup>20</sup> Institut de Physique Nucléaire de Lyon, IN2P3-CNRS, Université Claude Bernard, Villeurbanne, France

<sup>21</sup> III. Physikalisches Institut A, RWTH Aachen, Aachen, Germany

<sup>22</sup> Physikalisches Institut, Universität Bonn, Bonn, Germany

<sup>23</sup> Physikalisches Institut, Universität Freiburg, Freiburg, Germany

<sup>24</sup> Institut für Physik, Universität Mainz, Mainz, Germany

<sup>25</sup> Ludwig-Maximilians-Universität München, München, Germany

<sup>26</sup> Fachbereich Physik, University of Wuppertal, Wuppertal, Germany

<sup>27</sup> Panjab University, Chandigarh, India

<sup>28</sup> Delhi University, Delhi, India

<sup>29</sup> Tata Institute of Fundamental Research, Mumbai, India

<sup>30</sup> University College Dublin, Dublin, Ireland

- <sup>31</sup> Korea Detector Laboratory, Korea University, Seoul, Korea  
<sup>32</sup> CINVESTAV, Mexico City, Mexico  
<sup>33</sup> FOM-Institute NIKHEF and University of Amsterdam/NIKHEF, Amsterdam, The Netherlands  
<sup>34</sup> Radboud University Nijmegen/NIKHEF, Nijmegen, The Netherlands  
<sup>35</sup> Joint Institute for Nuclear Research, Dubna, Russia  
<sup>36</sup> Institute for Theoretical and Experimental Physics, Moscow, Russia  
<sup>37</sup> Moscow State University, Moscow, Russia  
<sup>38</sup> Institute for High Energy Physics, Protvino, Russia  
<sup>39</sup> Petersburg Nuclear Physics Institute, St. Petersburg, Russia  
<sup>40</sup> Lund University, Lund, Sweden, Royal Institute of Technology and Stockholm University, Stockholm, Sweden, and Uppsala University, Uppsala, Sweden  
<sup>41</sup> Lancaster University, Lancaster, United Kingdom  
<sup>42</sup> Imperial College, London, United Kingdom  
<sup>43</sup> University of Manchester, Manchester, United Kingdom  
<sup>44</sup> University of Arizona, Tucson, Arizona 85721, USA  
<sup>45</sup> Lawrence Berkeley National Laboratory and University of California, Berkeley, California 94720, USA  
<sup>46</sup> California State University, Fresno, California 93740, USA  
<sup>47</sup> University of California, Riverside, California 92521, USA  
<sup>48</sup> Florida State University, Tallahassee, Florida 32306, USA  
<sup>49</sup> Fermi National Accelerator Laboratory, Batavia, Illinois 60510, USA  
<sup>50</sup> University of Illinois at Chicago, Chicago, Illinois 60607, USA  
<sup>51</sup> Northern Illinois University, DeKalb, Illinois 60115, USA  
<sup>52</sup> Northwestern University, Evanston, Illinois 60208, USA  
<sup>53</sup> Indiana University, Bloomington, Indiana 47405, USA  
<sup>54</sup> University of Notre Dame, Notre Dame, Indiana 46556, USA  
<sup>55</sup> Iowa State University, Ames, Iowa 50011, USA  
<sup>56</sup> University of Kansas, Lawrence, Kansas 66045, USA  
<sup>57</sup> Kansas State University, Manhattan, Kansas 66506, USA  
<sup>58</sup> Louisiana Tech University, Ruston, Louisiana 71272, USA  
<sup>59</sup> University of Maryland, College Park, Maryland 20742, USA  
<sup>60</sup> Boston University, Boston, Massachusetts 02215, USA  
<sup>61</sup> Northeastern University, Boston, Massachusetts 02115, USA  
<sup>62</sup> University of Michigan, Ann Arbor, Michigan 48109, USA  
<sup>63</sup> Michigan State University, East Lansing, Michigan 48824, USA  
<sup>64</sup> University of Mississippi, University, Mississippi 38677, USA  
<sup>65</sup> University of Nebraska, Lincoln, Nebraska 68588, USA  
<sup>66</sup> Princeton University, Princeton, New Jersey 08544, USA  
<sup>67</sup> Columbia University, New York, New York 10027, USA  
<sup>68</sup> University of Rochester, Rochester, New York 14627, USA  
<sup>69</sup> State University of New York, Stony Brook, New York 11794, USA  
<sup>70</sup> Brookhaven National Laboratory, Upton, New York 11973, USA  
<sup>71</sup> Langston University, Langston, Oklahoma 73050, USA  
<sup>72</sup> University of Oklahoma, Norman, Oklahoma 73019, USA  
<sup>73</sup> Brown University, Providence, Rhode Island 02912, USA  
<sup>74</sup> University of Texas, Arlington, Texas 76019, USA  
<sup>75</sup> Southern Methodist University, Dallas, Texas 75275, USA  
<sup>76</sup> Rice University, Houston, Texas 77005, USA  
<sup>77</sup> University of Virginia, Charlottesville, Virginia 22901, USA  
<sup>78</sup> University of Washington, Seattle, Washington 98195, USA

(Dated: July 19, 2005)

We present a study of the decay  $B_s^0 \rightarrow J/\psi \phi$ . We obtain the CP-odd fraction in the final state at time zero,  $R_\perp = 0.16 \pm 0.10$  (stat)  $\pm 0.02$  (syst), the average lifetime of the  $(B_s^0, \bar{B}_s^0)$  system,  $\bar{\tau}(B_s^0) = 1.39_{-0.16}^{+0.13}$  (stat)  $_{-0.02}^{+0.01}$  (syst) ps, and the relative width difference between the heavy and light mass eigenstates,  $\Delta\Gamma/\bar{\Gamma} \equiv (\Gamma_L - \Gamma_H)/\bar{\Gamma} = 0.24_{-0.38}^{+0.28}$  (stat)  $_{-0.04}^{+0.03}$  (syst). With the additional constraint from the world average of the  $B_s^0$  lifetime measurements using semileptonic decays, we find  $\bar{\tau}(B_s^0) = 1.39 \pm 0.06$  ps and  $\Delta\Gamma/\bar{\Gamma} = 0.25_{-0.15}^{+0.14}$ . For the ratio of the  $B_s^0$  and  $B^0$  lifetimes we obtain  $\frac{\bar{\tau}(B_s^0)}{\bar{\tau}(B^0)} = 0.91 \pm 0.09$  (stat)  $\pm 0.003$  (syst).

PACS numbers: 13.25.Hw, 11.30.Er

Within the framework of the standard model (SM), the  $B_s^0$  mesons are expected to mix in such a way that the

mass and decay width differences between the heavy and light eigenstates,  $\Delta M \equiv M_H - M_L$  and  $\Delta\Gamma \equiv \Gamma_L - \Gamma_H$ , are sizeable. The mixing phase  $\delta\phi$  is small and to a good approximation the two mass eigenstates correspond to CP eigenstates. New phenomena may alter  $\delta\phi$ , leading to a reduction of the observed  $\Delta\Gamma/\bar{\Gamma}$  compared to the SM prediction [1].

The decay  $B_s^0 \rightarrow J/\psi \phi$ , proceeding through the quark process  $b \rightarrow c\bar{c}s$ , gives rise to both CP-even and CP-odd final states. It is possible to separate the two CP components of the decay  $B_s^0 \rightarrow J/\psi \phi$ , and thus to measure the lifetime difference, through a simultaneous study of the time evolution and angular distributions of the decay products of the  $J/\psi$  and  $\phi$  mesons. Angular distribution of  $B_s^0 \rightarrow J/\psi(\rightarrow \mu^+\mu^-) \phi(\rightarrow K^+K^-)$  involve three angles. Current statistics are such that the use of all three angles characterizing the final state is not yet beneficial. We use a variable particularly sensitive to separating the CP states, the cosine of the transversity polar angle (called "transversity"), as defined below.

The analysis of data collected with the DØ detector [2] at the Fermilab Tevatron collider presented in this Letter is an extension of a recently published study [3] done under the single  $B_s^0$  lifetime hypothesis. We perform an unbinned maximum likelihood fit to the data, including the  $B_s^0$  candidate mass, lifetime, and transversity, in the decay sequence  $B_s^0 \rightarrow J/\psi \phi$ ,  $J/\psi \rightarrow \mu^+\mu^-$ ,  $\phi \rightarrow K^+K^-$ . We extract three parameters characterizing the  $B_s^0$  system and its decay:  $\bar{\tau}(B_s^0) = 1/\bar{\Gamma}$ , where  $\bar{\Gamma} \equiv (\Gamma_H + \Gamma_L)/2$ ;  $\Delta\Gamma/\bar{\Gamma}$ ; and  $R_\perp$ , the relative rate of the decay to the CP-odd states at time zero. The *average* lifetimes of  $B_s^0$  and  $B^0$ , as defined above, are expected to be equal to within 1% [4], and their ratio is determined by measuring the lifetime of  $B^0$  in the similar decay topology of  $J/\psi K^*$ .

The data were collected between June 2002 and August 2004. The sample is selected by requiring two reconstructed muons with a transverse momentum  $p_T > 1.5$  GeV. Each muon is required to be detected as a track segment in at least one layer of the muon system and to be matched to a central track. One muon is required to have segments both inside and outside the toroid. We require the events to satisfy a muon trigger that does not include any cuts on the impact parameter. The sample corresponds to an integrated luminosity of approximately 450 pb<sup>-1</sup>.

To select the  $B_s^0$  candidate sample, we apply the following kinematic and quality cuts. Minimum values of momenta in the transverse plane for  $B_s^0$ ,  $\phi$ , and  $K$  mesons are set at 6.0 GeV, 1.5 GeV, and 0.7 GeV, respectively.  $J/\psi$  candidates are accepted if the invariant mass is in the range 2.90 – 3.25 GeV. Successful candidates are constrained to the average reconstructed  $J/\psi$  mass of 3.072 GeV. Decay products of the  $\phi$  candidates are required to satisfy a fit to a common vertex and to have an invariant mass in the range 1.01 – 1.03 GeV. We require the  $(J/\psi, \phi)$  pair to be consistent with coming from a com-

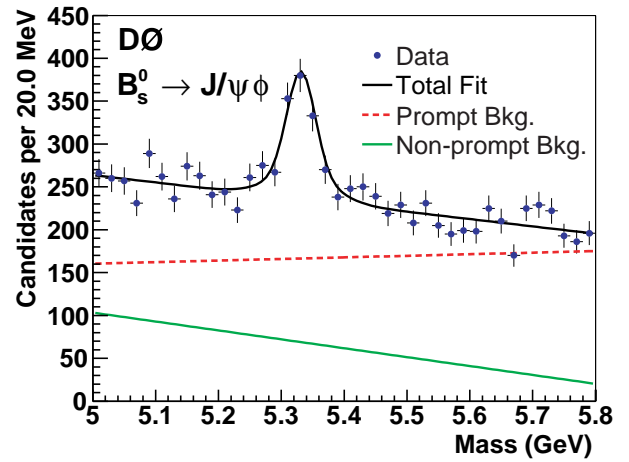


FIG. 1: The invariant mass distribution of the  $(J/\psi, \phi)$  system for  $B_s^0$  candidates. The curves are projections of the maximum likelihood fit (see text).

mon vertex, and to have an invariant mass in the range 5.0 – 5.8 GeV. In case of multiple  $\phi$  meson candidates, we select the one with the highest transverse momentum. Monte Carlo (MC) studies show that the  $p_T$  spectrum of the  $\phi$  mesons coming from  $B_s^0$  decay is harder than the spectrum of a pair of random tracks from the underlying event. We define the signed decay length of a  $B_s^0$  meson  $L_{xy}^B$  as the vector pointing from the primary vertex to the decay vertex projected on the  $B_s^0$  transverse momentum. To reconstruct the primary vertex, we select tracks with  $p_T > 0.3$  GeV that are not used as decay products of the  $B_s$  candidate and apply a constraint to the average beam spot position. The proper decay length,  $ct$ , is defined by the relation  $ct = L_{xy}^B \cdot M_{B_s^0}/p_T$  where  $M_{B_s^0}$  is the world average mass of the  $B_s^0$  meson [5]. The distribution of the proper decay length uncertainty  $\sigma(ct)$  of  $B_s^0$  mesons peaks around 25  $\mu\text{m}$ . We accept events with  $\sigma(ct) < 60$   $\mu\text{m}$ . There are 9699 events satisfying the above cuts.

The resulting invariant mass distribution of the  $(J/\psi, \phi)$  system is shown in Fig. 1. The curves are projections of the maximum likelihood fit, described below. The fit assigns  $513 \pm 33$  events to  $B_s^0$  decay.

Using the same data sample and analogous kinematic and quality cuts, we select a sample of 1913 events of the decay sequence  $B^0 \rightarrow J/\psi K^*$ ,  $J/\psi \rightarrow \mu^+\mu^-$ ,  $K^* \rightarrow K^\pm \pi^\mp$ , and update the  $B^0$  lifetime measurement reported in Ref. [3] with larger statistics.

We perform a simultaneous unbinned maximum likelihood fit to the proper decay length, transversity, and mass. The likelihood function  $\mathcal{L}$  is given by:

$$\mathcal{L} = \prod_{i=1}^N [f_{\text{sig}} \mathcal{F}_{\text{sig}}^i + (1 - f_{\text{sig}}) \mathcal{F}_{\text{bck}}^i], \quad (1)$$

where  $N$  is the total number of events,  $\mathcal{F}_{\text{sig}}^i$  ( $\mathcal{F}_{\text{bck}}^i$ ) is the product of the mass, proper decay length, and the

transversity probability density functions for the signal (background), and  $f_{\text{sig}}$  is the fraction of signal in the sample. Background is divided into two categories, based on their origin and lifetime characteristics. “Prompt” background is due to directly produced  $J/\psi$  mesons accompanied by random tracks arising from hadronization. This background is distinguished from “non-prompt” background, where the  $J/\psi$  meson is a product of a B-hadron decay while the tracks forming the  $\phi$  candidate emanate from a multibody decay of the same B hadron or from the underlying event. We allow for independent parameters for the two background components in mass, lifetime, and transversity. There are nineteen free parameters in the fit.

For the signal mass distribution, we use a sum of two Gaussian functions with a fixed ratio of widths and normalizations, obtained in a fit to the signal-dominated

subset satisfying  $ct/\sigma(ct) > 5$ . We allow for two free parameters, the common mean value and the width of the narrow component. The lifetime distribution of the signal is parametrized by an exponential convoluted with a Gaussian function with the width taken from the event-by-event estimate of  $\sigma(ct)$ . To allow for the possibility of the lifetime uncertainty to be systematically underestimated, we introduce a free scale factor.

The transversity distribution of the signal is determined in the following way. The time-dependent three-angle distribution for the decay of *untagged*  $B_s^0$  mesons, i.e., summed over  $B_s^0$  and  $\bar{B}_s^0$ , expressed in terms of the linear polarization amplitudes  $|A_x(t)|$  and their relative phases  $\delta_i$  is [6]:

$$\begin{aligned} \frac{d^3\Gamma(t)}{d\cos\theta\,d\varphi\,d\cos\psi} &\propto 2|A_0(0)|^2 e^{-\Gamma_L t} \cos^2\psi (1 - \sin^2\theta \cos^2\varphi) + \sin^2\psi \{ |A_{\parallel}(0)|^2 e^{-\Gamma_L t} (1 - \sin^2\theta \sin^2\varphi) \\ &\quad + |A_{\perp}(0)|^2 e^{-\Gamma_H t} \sin^2\theta \} + \frac{1}{\sqrt{2}} \sin 2\psi |A_0(0)| |A_{\parallel}(0)| \cos(\delta_2 - \delta_1) e^{-\Gamma_L t} \sin^2\theta \sin 2\varphi \\ &\quad + \left\{ \frac{1}{\sqrt{2}} |A_0(0)| |A_{\perp}(0)| \cos\delta_2 \sin 2\psi \sin 2\theta \cos\varphi - |A_{\parallel}(0)| |A_{\perp}(0)| \cos\delta_1 \sin^2\psi \sin 2\theta \sin\varphi \right\} \frac{1}{2} (e^{-\Gamma_H t} - e^{-\Gamma_L t}) \delta\phi. \quad (2) \end{aligned}$$

In the coordinate system of the  $J/\psi$  rest frame (where the  $\phi$  meson moves in the  $x$  direction, the  $z$  axis is perpendicular to the decay plane of  $\phi \rightarrow K^+ K^-$ , and  $p_y(K^+) \geq 0$ ), the transversity polar and azimuthal angles  $(\theta, \varphi)$  describe the direction of the  $\mu^+$ , and  $\psi$  is the angle between  $\vec{p}(K^+)$  and  $-\vec{p}(J/\psi)$  in the  $\phi$  rest frame.

We model the acceptance in the three angles by polynomials, with parameters determined using Monte Carlo simulations. We have used the *SVV\_HELAMP* model in the *EVTGEN* generator [7], interfaced to the *PYTHIA* program [8]. Reconstructed events were reweighted to match the kinematic distributions with the data.

To obtain the one-angle (transversity) distribution, we integrate the three-angle distribution over the angles  $\psi$  and  $\varphi$ . The resulting distribution depends on one free parameter,  $R_{\perp} = |A_{\perp}(0)|^2$ . There is a small correction term due to the nonuniformity of the acceptance in the angle  $\varphi$ , which is proportional to  $|A_0(0)|^2 - |A_{\parallel}(0)|^2$ . We use the CDF Collaboration measurement [9] of this difference,  $0.355 \pm 0.066$ .

The lifetime shape of the background is described as a sum of a prompt component, simulated as a Gaussian function centered at zero, and a non-prompt com-

ponent, simulated as a superposition of one exponential for the negative  $ct$  region and two exponentials for the positive  $ct$  region, with free slopes and normalization. The mass distributions of the backgrounds are parametrized by first-order polynomials. The transversity distributions of backgrounds are parametrized as  $(1 + a_2 \cos^2\theta + a_4 \cos^4\theta)$ .

Results of the fit are presented in Figs. 1 – 4. The proper decay length distribution, and the transversity distribution, both with the fit results overlaid are shown in Figs. 2 and 3. Figure 4 shows the one standard deviation (one- $\sigma$ ) contour for  $c\bar{\tau}(B_s^0)$  versus  $\Delta\Gamma/\bar{\Gamma}$ . It provides the best display of the uncertainty range for these correlated parameters. Our best fit returns  $R_{\perp} = 0.16 \pm 0.10$  and  $\Delta\Gamma/\bar{\Gamma} = 0.24_{-0.38}^{+0.28}$  at  $\bar{\tau}(B_s^0) = 1.39_{-0.16}^{+0.13}$  ps.

We do a series of alternative fits, at discrete values of  $\bar{\tau}(B_s^0)$ . The results for  $\Delta\Gamma/\bar{\Gamma}$ , its one standard deviation range, and the corresponding value of the likelihood, are listed in Table I. We verify the procedure by performing fits on a sample of approximately 50,000 MC events passed through the full chain of detector simulation, event reconstruction, and maximum likelihood fitting. We see no bias in the event reconstruction or

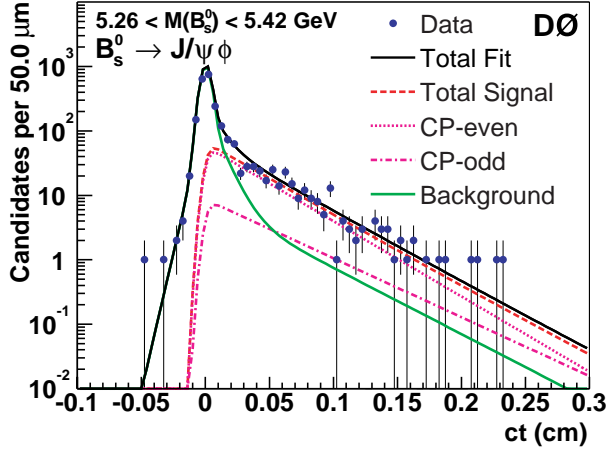


FIG. 2: The proper decay length  $ct$  of the  $B_s^0$  candidates in the signal mass region. The curves show the signal contribution, dashed (red); the background, lower solid line (green); and total, upper solid line (black) in the signal mass region.

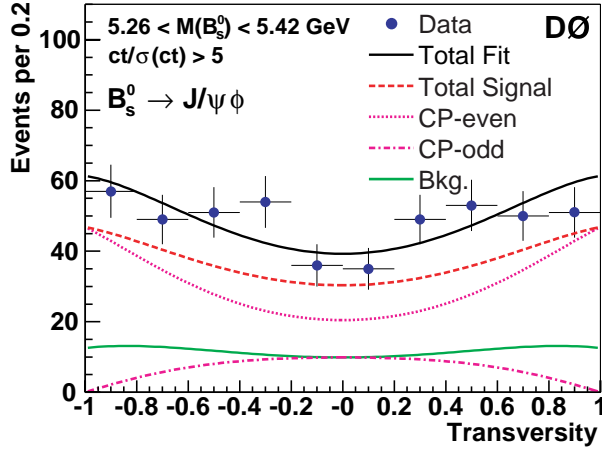


FIG. 3: The distribution of the cosine of the transversity angle in the signal mass region, for “non-prompt” events, with the results of the maximum likelihood fit overlaid.

in the fitting procedure. The fits reproduce the inputs ( $c\tau = 439 \mu\text{m}$ ,  $\Delta\Gamma/\bar{\Gamma} = 0$ , and a range of  $R_\perp$  between 0 and 1) correctly within the statistical precision of  $2 \mu\text{m}$  for  $c\tau$ , 0.01 for  $R_\perp$ , and 0.025 for  $\Delta\Gamma/\bar{\Gamma}$ . We test the sensitivity of the results to the parametrization of the signal and background mass distributions by varying the parameters of the two-Gaussian function. To test the sensitivity of the results to the background model, we add a quadratic term in the background mass distribution. We find a non-negligible effect from the extra term in the non-prompt background on  $c\tau$  and  $\Delta\Gamma/\bar{\Gamma}$ . We have also tested the sensitivity of the results to the assumption that the lifetime and the transversity distributions of background are independent of mass. The effect of the uncertainty of the detector alignment on the lifetime measurement was estimated in Ref. [3]. The effects of systematic uncertainties are listed in Table II.

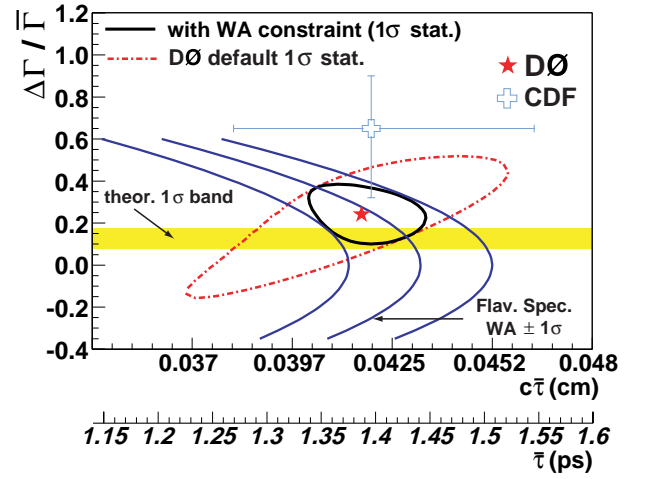


FIG. 4: The DØ default one- $\sigma$  (stat.) contour ( $\delta \ln(L) = 0.5$ ) compared to a one- $\sigma$  band for the world average (WA) measurement based on flavor-specific decays,  $\tau_{fs} = 1.442 \pm 0.066$  ps. A simultaneous fit to our data and the WA gives a one- $\sigma$  range  $\bar{\tau}(B_s^0) = 1.39 \pm 0.06$  ps and  $\Delta\Gamma/\bar{\Gamma} = 0.25^{+0.14}_{-0.15}$ . The SM theoretical prediction is shown as the horizontal band.

TABLE I: Fit results for  $\Delta\Gamma/\bar{\Gamma}$  at fixed values of  $\bar{\tau}(B_s^0)$ . For each assumed value of  $\bar{\tau}(B_s^0)$ , the likelihood as function of  $\Delta\Gamma/\bar{\Gamma}$  is symmetric and parabolic.

$\bar{\tau}(B_s^0)$ (ps)	$\Delta\Gamma/\bar{\Gamma}$	$\Delta \ln(\mathcal{L})$
1.23	$-0.13 \pm 0.15$	0.51
1.27	$-0.03 \pm 0.17$	0.32
1.31	$0.07 \pm 0.19$	0.17
1.35	$0.16 \pm 0.21$	0.04
1.39	$0.24 \pm 0.20$	0.0
1.43	$0.31 \pm 0.19$	0.06
1.47	$0.37 \pm 0.18$	0.20
1.51	$0.43 \pm 0.18$	0.42
1.55	$0.48 \pm 0.18$	0.69

We also conduct a test with an ensemble of 1000 pseudo-experiments with similar statistical sensitivity, chosen from the distribution described by Eq. 1, with the same parameters as obtained in this analysis. Both the spread of uncertainties and of the central values of the fit parameters are in good agreement with the results reported here. Our results are consistent with the CDF Collaboration results [9], also shown in Fig. 4.

$B_s^0$  lifetime measurements from semileptonic (flavor-specific) data provide an independent constraint on the average lifetime and lifetime difference in the  $B_s^0$  system. The world average [5]  $B_s^0$  lifetime is  $\tau_{fs} = 1/\Gamma_{fs} = 1.442 \pm 0.066$  ps. This result is based on single-exponential fits in the flavor-specific decay channels, which determine the following relation [10] (shown in Fig. 4) of  $\bar{\Gamma}$  and  $\Delta\Gamma/\bar{\Gamma}$ :  $\Gamma_{fs} = \bar{\Gamma} - (\Delta\Gamma)^2/2\bar{\Gamma} + \mathcal{O}(\Delta\Gamma)^3/\bar{\Gamma}^2$ . Applying the above constraint to our measurement, we obtain  $\bar{\tau}(B_s^0) = 1.39 \pm 0.06$  ps and  $\Delta\Gamma/\bar{\Gamma} = 0.25^{+0.14}_{-0.15}$ . This result is consistent with the SM expectation [11] of

TABLE II: Sources of systematic uncertainty. The numbers reflect the variation of the fitted central values associated with the one- $\sigma$  variation of the corresponding external input parameters. The second item includes contributions from the variation of the acceptance as a function of  $\varphi$  and  $\psi$ , as well as from a one- $\sigma$  variation of the quantity  $|A_0(0)|^2 - |A_{||}(0)|^2$ .

Source	$c\tau(B_s^0), \mu\text{m}$	$\Delta\Gamma/\bar{\Gamma}$	$R_\perp$
Acceptance vs. $\cos\theta$	$\pm 0.6$	$\pm 0.001$	$\pm 0.005$
Integration over $\varphi, \psi$	$\pm 0.2$	$\pm 0.001$	$\pm 0.02$
Procedure test	$\pm 2.0$	$\pm 0.025$	$\pm 0.01$
Momentum scale	$-3.0$	—	—
Signal mass model	$\pm 1.0$	$+0.009, -0.017$	$\pm 0.007$
Background mass	$-3.5$	$+0.02$	$-0.002$
Detector alignment	$\pm 2.0$	—	—
Background model	$\pm 0.5$	$\pm 0.016$	$\pm 0.005$
Total	$-5.6, +3.1$	$-0.04, +0.03$	$\pm 0.02$

$0.12 \pm 0.05$ .

All the results presented above are obtained under a tacit assumption that the CP-violating phase is negligible, as predicted by the SM ( $\delta\phi = \phi_{\text{CKM}} = -0.03$ ). Future improvements on the measurement of  $\Delta\Gamma/\bar{\Gamma}$  may exclude models predicting large deviations of  $\delta\phi$  from the SM value.

In summary, we have measured the CP-odd fraction for the decay  $B_s^0 \rightarrow J/\psi \phi$ , and the correlated parameters of the average lifetime of the  $(B_s^0, \bar{B}_s^0)$  system  $\bar{\tau}(B_s^0) = 1/\bar{\Gamma}$ , and the relative width difference  $\Delta\Gamma/\bar{\Gamma}$ , or, equivalently, the mean lifetimes of the light and heavy  $B_s^0$  eigenstates, respectively. We obtain

$$\begin{aligned}
 R_\perp &= 0.16 \pm 0.10 \text{ (stat)} \pm 0.02 \text{ (syst)}, \\
 \Delta\Gamma/\bar{\Gamma} &= 0.24_{-0.38}^{+0.28} \text{ (stat)} {}_{-0.04}^{+0.03} \text{ (syst)}, \\
 \bar{\tau}(B_s^0) &= 1.39_{-0.16}^{+0.13} \text{ (stat)} {}_{-0.02}^{+0.01} \text{ (syst) ps}, \\
 \tau_L &= 1.24_{-0.11}^{+0.14} \text{ (stat)} {}_{-0.02}^{+0.01} \text{ (syst) ps}, \\
 \tau_H &= 1.58_{-0.42}^{+0.39} \text{ (stat)} {}_{-0.02}^{+0.01} \text{ (syst) ps}.
 \end{aligned}$$

We have updated the measurement of the mean lifetime of the  $B^0$  meson with doubled statistics. With the systematic uncertainty estimated in Ref. [3], the updated measurement is

$$\tau(B^0) = 1.530 \pm 0.043 \text{ (stat)} \pm 0.023 \text{ (syst) ps}.$$

For the ratio of the average  $B_s^0$  lifetime to the  $B^0$  life-

time, we obtain

$$\frac{\bar{\tau}(B_s^0)}{\tau(B^0)} = 0.91 \pm 0.09 \text{ (stat)} \pm 0.003 \text{ (syst)}.$$

We thank the staffs at Fermilab and collaborating institutions, and acknowledge support from the DOE and NSF (USA); CEA and CNRS/IN2P3 (France); FASI, Rosatom and RFBR (Russia); CAPES, CNPq, FAPERJ, FAPESP and FUNDUNESP (Brazil); DAE and DST (India); Colciencias (Colombia); CONACyT (Mexico); KRF (Korea); CONICET and UBACyT (Argentina); FOM (The Netherlands); PPARC (United Kingdom); MSM (Czech Republic); CRC Program, CFI, NSERC and WestGrid Project (Canada); BMBF and DFG (Germany); SFI (Ireland); Research Corporation, Alexander von Humboldt Foundation, and the Marie Curie Program.

- 
- [\*] Visitor from University of Zurich, Zurich, Switzerland.
- [1] I. Dunietz, R. Fleischer, and U. Nierste, Phys. Rev. D **63**, 114015 (2001).
  - [2] DØ Collaboration, V. Abazov *et al.*, “The Upgraded DØ Detector”, submitted to Nucl. Instrum. Methods Phys. Res. A.
  - [3] DØ Collaboration, V. M. Abazov *et al.*, Phys. Rev. Lett. **94**, 042001 (2005).
  - [4] I. I. Bigi and N. G. Uraltsev, Phys. Lett. B **280**, 271 (1992).
  - [5] S. Eidelman *et al.* (Particle Data Group), Phys. Lett. B **592**, 1 (2004) and 2005 partial update for edition 2006; <http://pdg.lbl.gov> 2005.
  - [6] A. S. Dighe, I. Dunietz, and R. Fleischer, Eur. Phys. J. C **6**, 647 (1999).
  - [7] A. Ryd and D. Lange, <http://www.slac.stanford.edu/lange/EvtGen> 2000.
  - [8] T. Sjöstrand *et al.*, Comp. Phys. Comm. **135**, 238 (2001).
  - [9] CDF Collaboration, D. Acosta *et al.*, Phys. Rev. Lett., **94**, 101803 (2005).
  - [10] K. Anikeev *et al.*, FERMILAB-Pub-01/197, hep-ph/0201071, p. 360.
  - [11] A. Lenz, hep-ph/0412007.